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Irrigation water quality and zinc on growth and yield of fenugreek (*Trigonella foenum-graecum* L.)

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Abstract

A pot experiment was carried out to find out the influence of different Residual Sodium Carbonate (RSC) water and zinc (Zn) levels on growth and yield of fenugreek. The study involved 12 treatment combinations of four RSC levels of irrigation water (W_1=1, W_2=2.5, W_3=5.0 & W_4=7.5 mmol L^{-1}) and three Zn levels (Z_0=control, Z_{10}= 10 & Z_{20}= 20 mg kg^{-1} soil). Results revealed that the plant height, number of pods $plant^{-1}$, number of seeds pod^{-1}, test weight, seed yield and straw yield of fenugreek significantly decreased with all levels of RSC water and increased with increasing levels of Zn. Thus, application of 20 mg kg^{-1} Zn under 2.5 mM L^{-1} of RSC water was found to be superior with respect to growth and yield of fenugreek.

Keywords: fenugreek, residual sodium carbonate water, yield, zinc

Introduction

High residual sodium carbonate (RSC) irrigation water is characterized by sodium carbonate as a predominant salt. The prolonged use of such water immobilizes soluble Ca and Mg in the soil by precipitating them as carbonates. Consequently, the concentration of Na in the soil solution and exchangeable complex increases and leads to the development of sodic conditions. The use of sodic water for irrigation adversely affects productivity of soil by influencing the uptake of nutrients (Chauhan *et al*. 1988). In many parts of the country, zinc (Zn) as a plant nutrient stands third in importance next to N and P (Takkar & Randhawa 1980). Zn helps in inducing alkalinity tolerance in crops by enhancing crops efficiency to utilize K and Ca. Thus, reducing of Na/K and Na/Ca ratio in plant tissues to mitigate the adverse effect of alkalinity in crop is an important aspect (Misra 2001). Fenugreek is fairly tolerant to salinity (Habib *et al*. 1971) but tolerance to sodicity is not known. No systematic study has been conducted on application of Zn with high RSC irrigation water in light textured soils for cultivation of fenugreek.

Materials and methods

The pot experiment was conducted at S.K.N. College of Agriculture, Jobner (Rajasthan) during *Rabi*, 2005–2006. The soil was loamy sand and the experiment consisted of 12

treatment combinations of four RSC (Residual Sodium Carbonate) levels of irrigation water (W_1=1, W_2=2.5, W_3=5.0 & W_4=7.5 mM L^{-1}) and three Zn levels (Z_0=control, Z_{10}= 10 & Z_{20}= 20 mg kg^{-1} soil) laid out in Completely Randomized Design (CRD) with three replications. The different RSC water were prepared artificially by dissolving required amount of $NaHCO_3$, NaCl, Na_2SO_4 and $MgCl_2$ in irrigation water (control) and Zn was applied basally through $ZnSO_4.7H_2O$. Ten fenugreek seeds per pot of variety RMt-1 were sown on 8th November 2005 and after germination, only three plants per pot were maintained. Different observations related to growth and yield attributes and nutrient content (N, P, K, Zn, Fe and Na) in plants were carried out using standard methodology.

Results and discussion

Plant height, number of pods $plant^{-1}$, number of seeds pod^{-1}, test weight, seed yield and straw yield of fenugreek significantly decreased with increasing levels of RSC water (Table 1). This may be because increasing levels of RSC water increased the Exchangeable Sodium Percentage (ESP) and pH of soil (Table 4) resulting in decreased availability of P, K, Zn and Fe but increased uptake of Na. The higher amount of Na may adversely affect the physiological, metabolic and enzymatic activities and utilization of photosynthates in plant. There are several evidences that cationic (Ca, Mg, Na and K) imbalance could lead to disturbances in photosynthesis and activity of metalloenzymes (Plaut & Grieve 1988). The use of high RSC water increased the exchangeable Na in soil which also had detrimental effect on physical condition of soil resulting in poor root development and plant growth (Chauhan & Prasad 2003) and decreased seed and straw yield of fenugreek.

Significant improvements in plant height, number of pods $plant^{-1}$, number of seeds pod^{-1}, test weight, seed yield and straw yield were observed with increasing levels of applied Zn (Table 1). The favourable influence of applied Zn on these characters may be explained by its catalytic or stimulatory effect on most of the physiological and metabolic process of plants (Deb & Sakal 2002). The increase in yield attributes might be due to the role of Zn in biosynthesis of Indole Acetic Acid (IAA) and especially due to its role in initiation of primordial for reproductive parts and partitioning of photosynthates towards them (Deb & Sakal 2002).

Table 1. Effect of different RSC and Zn levels on growth and yield attributes of fenugreek

Treatments	Plant height (cm)	No. of pods $plant^{-1}$	No. of seeds pod^{-1}	Test weight (g)	Seed yield (g pot^{-1})	Straw yield (g pot^{-1})	Protein in seed (%)
RSC level							
W_1	38.54	28.88	13.35	11.37	12.59	24.67	18.71
W_2	37.31	27.88	12.80	10.91	11.51	21.68	20.01
W_3	33.77	26.56	12.03	9.86	9.92	18.37	20.93
W_4	31.59	25.34	11.34	9.01	7.52	12.85	21.36
SEm±	0.449	0.413	0.215	0.183	0.147	0.278	0.302
CD (P<0.05)	1.311	1.203	0.629	0.535	0.429	0.810	0.883
Zn levels							
Zn_0	33.87	22.63	11.10	9.47	8.52	15.01	19.63
Zn_{10}	35.27	27.75	12.78	10.41	10.40	19.46	19.88
Zn_{20}	36.77	31.13	13.34	10.97	12.24	23.66	21.25
SEm±	0.389	0.357	0.187	0.159	0.127	0.240	0.262
CD (P<0.05)	1.135	1.043	0.545	0.469	0.371	0.702	0.765

W_1=1.0 mM L^{-1}; W_2=2.5 mM L^{-1}; W_3=5.0 mM L^{-1}; W_4=7.5 mM L^{-1}; Zn_0=no Zn; Zn_{10}=10 mg Zn kg^{-1}; Zn_{20}=20 mg Zn kg^{-1} soil

Table 2. Interactive effect of different RSC water and zinc levels on seed and straw yield

Treatments	Seed yield (g pot^{-1})			Straw yield (g pot^{-1})		
	Zn_0	Zn_{10}	Zn_{20}	Zn_0	Zn_{10}	Zn_{20}
W_1	10.17	12.68	14.92	19.32	25.36	29.33
W_2	9.36	11.56	13.61	16.85	21.97	26.22
W_3	8.17	9.92	11.68	13.89	17.86	23.36
W_4	6.37	7.43	8.75	10.19	12.63	15.73
SEm±	0.254			0.481		
CD (P<0.05)	0.742			1.403		

W_1=1.0 mM L^{-1}; W_2=2.5 mM L^{-1}; W_3=5.0 mM L^{-1}; W_4=7.5 mM L^{-1}; Zn0=no Zn; Zn10=10 mg Zn kg^{-1}; Zn20=20 mg Zn kg^{-1} soil

N and Na content in seed and straw increased significantly with increasing level of RSC water (Table 3). The increase in N content may be attributed to low availability of N to plant causing stunted growth and development due to high levels of RSC resulting in higher concentration of N in plant. According to Strogonov & Okinia (1961), the N taken up by plants is not utilized and gets accumulated as protein and is not available for plant growth, leading to increased content of N in seed and straw. Contrary to N, the P, K, Zn and Fe contents in seed and straw decreased due to application of different levels of RSC in irrigation water (Table 3). This might be due to fact that RSC rich water increased the ESP and pH of soil (Table 4). The higher sodicity of the soil could have decreased the mobility of P, K, Zn and Fe due to presence of CO_3 ions (Sharma 2003).

The increasing levels of Zn application significantly increased the N, K and Zn contents in seeds and straw of fenugreek while, P, Fe and Na contents decreased significantly (Table 3). Significant response of fenugreek to $ZnSO_4$ upto 20 mg kg^{-1} could be directly attributed to enhanced availability of nutrients due to chemical reclamation of soil by addition of $ZnSO_4$. The favourable effect of Zn on photosynthates and their translocation to different plant parts including seed ultimately

Table 3. Effect of different RSC water and Zn levels on N, P, K, Zn, Fe and Na concentration in seed and straw of fenugreek

Treatments	N (%)		P (%)		K (%)		Zn (mg kg^{-1})		Fe (mg kg^{-1})		Na (%)	
	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw
RSC level												
W_1	2.993	0.769	0.459	0.149	0.987	1.255	26.68	17.66	147.15	247.62	0.341	0.439
W_2	3.202	0.800	0.449	0.142	0.967	1.245	25.84	17.19	145.43	238.82	0.346	0.463
W_3	3.348	0.861	0.427	0.130	0.933	1.220	23.34	16.23	142.47	224.24	0.365	0.541
W_4	3.417	1.005	0.389	0.112	0.861	1.159	19.34	13.96	137.92	206.67	0.398	0.646
SEm±	0.048	0.015	0.007	0.002	0.011	0.008	0.358	0.242	0.935	3.86	0.004	0.009
CD (P<0.05)	0.139	0.045	0.020	0.006	0.033	0.024	1.045	0.706	2.720	11.25	0.011	NS
Zn level												
Zn_0	3.140	0.733	0.522	0.158	0.895	1.191	21.10	14.27	152.64	250.30	0.377	0.540
Zn_{10}	3.180	0.877	0.427	0.130	0.925	1.205	24.18	15.77	145.44	227.70	0.363	0.515
Zn_{20}	3.400	0.966	0.345	0.111	0.990	1.264	26.11	18.73	161.65	210.00	0.348	0.502
SEm±	0.048	0.013	0.006	0.002	0.010	0.007	0.310	0.209	0.810	3.34	0.003	0.008
CD (P<0.05)	0.139	0.039	0.018	0.005	0.058	0.021	0.905	0.611	2.360	9.75	0.010	0.024

W_1=1.0 mM L^{-1}; W_2=2.5 mM L^{-1}; W_3=5.0 mM L^{-1}; W_4=7.5 mM L^{-1}; Zn_0=no Zn; Zn_{10}=10 mg Zn kg^{-1}; Zn_{20}=20 mg Zn kg^{-1} soil

Table 4. Effect of different RSC water and Zn levels on Ece, pH and ESP of soil after harvest of crop

Treatments	Ece (dSm^{-1})	pH	ESP
RSC level			
W_1	3.00	8.03	17.21
W_2	2.81	8.22	18.31
W_3	2.46	8.52	19.81
W_4	2.21	8.92	21.01
SEm±	0.08	0.10	0.40
CD (P<0.05)	0.24	0.29	1.15
Zn level			
Zn_0	2.36	8.53	19.25
Zn_{10}	2.58	8.43	19.15
Zn_{20}	2.91	8.30	18.85
SEm±	0.07	0.09	0.34
CD (P<0.05)	0.21	NS	NS

W_1=1.0 mM L^{-1}; W_2=2.5 mM L^{-1}; W_3=5.0 mM L^{-1}; W_4=7.5 mM L^{-1}; Zn_0=no Zn; Zn_{10}=10 mg Zn kg^{-1}; Zn_{20}=20 mg Zn kg^{-1}

increased the concentration of nutrients in the seed. The concentration of P, Fe and Na in seed and straw of fenugreek decreased with increasing levels of Zn. It might be due to the antagonistic relationship of Zn and P. The increased concentration of Zn decreased the absorption and translocation of P from the roots to the above parts. The results obtained supported the findings of Singh *et al*. (1988). The Na concentration decreased with $ZnSO_4$ application due to preferential translocation of K at the expense of Na due to chemical reclamation which is reflected in the Na/K ratio, which decreased with $ZnSO_4$ application.

The interactive effect of RSC water and Zn levels on seed and straw yield was found to be significant (Table 2). The data revealed that both seed and straw yield increased significantly with increase in Zn level at all RSC levels. The magnitude of decrease in seed and straw yield with increasing RSC in water was less at higher levels of Zn application. This indicated that harmful effects of RSC water can be mitigated by applying higher dose of Zn. This might be due to the fact that the high pH and ESP of soil due to RSC water decreased the availability of Zn and in such circumstances, the addition of Zn increased the availability of Zn to plants. Thus, it is inferred that application of 20 mg Zn kg^{-1} and 2.5 mM L^{-1} of RSC water ensured satisfactory growth and yield of fenugreek in light textured soil under semi-arid conditions.

References

Chauhan R P S, Bhudayal & Chauhan C P S 1988 Ameliorating effect of rain on sodic-water irrigated soil. J. Indian Soc. Soil Sci. 36: 590–592.

Chauhan R P S & Prasad K 2003 Impact of Mg/Ca ratio at varying levels of SAR and electrolytic concentration in water on sodification of montmorillonitic heavy soil. Ann. Pl. Soil Res. 5: 27–30.

Deb D L & Sakal R 2002 Mieronutrients. In: Sekhon G S, Chhonkar P K, Das D K, Goswami N N, Narayanasamy G, Poonia S R, Rattan R K & Sehgal J (Eds.), Fundamentals of Soil Science (pp.391–404), Indian Society of Soil Science, New Delhi..

Habib A F, Swamy R J & Mensinkai S W 1971 Salt tolerance in methi at germination stage. Cur. Sci. 40: 67.

Misra S K 2001 Salt tolerance of different cultivars of chick pea as influenced by zinc fertilization. J. Indian Soc. Soil Sci. 49: 135–140.

Plaut Z & Grieve C M 1988 Photosynthesis of salt-stressed maize as influenced by Ca: Na ratios in the nutrient solution. Pl. Soil. 105: 283–286.

Sharma G K 2003 Role of soil applied gypsum in reducing toxic effects of boron and SAR of irrigation water on wheat under sodic soil. Ph.D. Thesis, Rajasthan Agricultural University, Bikaner.

Singh S P, Takkar P N & Nayyar V K 1988 Evaluation of DTPA soil test for monitoring response of wheat to zinc on alluvial derived soils of South-West Punjab. J. Indian Soc. Soil Sci. 36: 383–385.

Strogonov B P & Okinia E Z 1961 Study on the dormancy of plant under conditions of irrigation with sodic solution. Fiziol Rest. 8: 79–85.

Takkar P N & Randhawa N S 1980 Zinc deficiency in Indian soils and plants. In: Proceedings of Seminar on Zinc Wastes and their Utilization (pp.13–15), 15-16 October, Indian Lead-Zinc Information Centre, Fertilizer Association of India, New Delhi, India.